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Penile Revascularization in the Treatment of Impotence

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New clinical developments in the diagnosis and treatment of male sexual dysfunction have occurred in the past several years. Much of this information has not been disseminated to the general medical public. Of particular note, a series of reliable penile prosthetic devices for the treatment of advanced erectile dysfunction is now considered to be established and valid surgical therapy.

The new diagnostic techniques of nocturnal penile tumescence monitoring, penile plethysmography, penile sphygmomanometry and phalloarteriography are beginning to show that some patients with erectile impotence have arteriosclerosis of the penile arteries. These patients were formerly considered to have psychogenic or idiopathic impotence. Some of these patients with vasculogenic impotence may benefit from the new surgical technique of penile revascularization, thus obviating the need for penile prosthetic implants.

A preliminary report of a small series of cases of corpus cavernosum revascularization using the microsurgical implantation of the inferior epigastric artery directly into the corpus cavernosum with prolonged systemic anticoagulation gives a cure/improvement rate of 40 percent. Better selection of patients for operation and perfection of surgical technique offer the chance for improvement in this rate of success. The proper role of corpus cavernosum revascularization in the treatment of impotence remains to be clearly defined. However, these preliminary results, coupled with several reports from Europe, are sufficiently encouraging to justify continued clinical investigation and surgical experience with penile revascularization for vasculogenic impotence.

SCIENTIFIC INTEREST and research in male reproductive physiology have been limited until recently and are only now beginning to establish a foothold of respectability with the lay and medical public. Curiously, this lack of interest has occurred despite universal cultural emphasis on fertility and male sexual prowess. Search for improvement or preservation of sexual powers dates to time immemorial[1] and, even today, folk tales and folk medicine throughout the world are replete with sexual witchcraft and home remedies. For example, the reputed aphrodisiac power of powdered rhinoceros horn is causing widespread poaching and the threatened extinction of rhinoceroses in Africa and India; "cell therapy" is used in Germany for sexual rejuvenation, pur-

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ABBREVIATIONS USED IN TEXT
CCR = corpus cavernosum revascularization
EC = epigastricocavernostomy
IEA = inferior epigastric artery

portedly induced by the subcutaneous implantation of fetal testis cells from lambs into humans; and a Chinese herbal medicine called Seahorse Genital Tonic Pills, composed of such ingredients as seahorse, ginseng, horse penis and testis, antler, tiger bone, deer sinew and gecko, is sold in San Francisco for "strengthening the genital functions."

Legitimate sexual medicine has made significant advances recently both in Europe and in the United States. Many of these advances have important clinical relevance but have yet to be disseminated to the medical public.

Of particular note, the 1970's saw the development of a series of surgically implanted penile prostheses for the treatment of organic impotence. The semirigid rod prosthetic device (Small-Carrion, Finney and others) and the inflatable prosthetic device have restored sexual function to thousands of men with advanced erectile dysfunction and have been accepted now as established and valid surgical therapies. Penile prosthetic implantation, however, is not a happy solution for all impotent patients. Some men with incomplete, yet incapacitating, organic impotence—and some with total impotence—consider implantation of prosthetic materials, and the frequent concomitant destruction of any remaining erectile capacity,[2] objectionable and unacceptable.

The new diagnostic techniques of nocturnal penile tumescence monitoring, penile sphygmomanometry, penile plethysmography and phalloarteriography are beginning to show that many men previously thought to have psychogenic or idiopathic impotence actually have vasculogenic impotence due to arteriosclerotic obstruction of the small vessels in the internal pudendal or penile arterial tree, or both. Further support for the new concept of arteriosclerosis of the penile vessels comes from the studies of Ruzbarsky and Michal,[3] who showed the occurrence of fibrosis and calcification of the intima and media and luminal narrowing of the penile arterial tree related to aging and diabetes, and of Benson and co-workers,[4] who have shown that penile "polsters" are probably arteriosclerotic structures that occur with aging. The incidence of penile arteriosclerosis is unknown, but current estimates without statistical basis are that perhaps 25 percent of impotent patients have small-vessel vasculogenic impotence.

Some patients with penile arteriosclerosis may be helped by a new surgical technique, corpus cavernosum revascularization (CCR), which avoids the use of prosthetic devices. Surgical revascularization of the corpus cavernosum has the potential to increase penile blood flow sufficiently to allow improvement in erectile function and resumption of sexual intercourse. The concept of revascularizing the corpus cavernosum for vasculogenic impotence was originated in Prague, Czechoslovakia, by V. Michal.[5] The theoretical basis of the operation is to increase basal penile blood flow to just below the threshold value necessary to initiate erection. This threshold has been shown by Michal to be approximately 93 ml per minute.[5] Then, with further sexual stimulation, the patient's own remaining capacity to increase penile blood flow, even if reduced, adds sufficient flow to exceed the threshold value and create an erection. Once achieved, the erection should be maintained, since the flow required for maintenance of erection is about half that required for initiation of erection.[5]

Corpus cavernosum revascularization is appealing to many patients because it offers the chance to achieve normal innate erections without the use of prosthetic materials and without long-term risks, even in the event of operative failure. A variety of surgical techniques to revascularize the corpus cavernosum have been used. These include direct anastomosis of the inferior epigastric artery (IEA) to the corpus cavernosum or epigastricocavernostomy (EC), saphenous or basilic vein graft between the IEA and corpus cavernosum and similar venous grafts from the femoral artery to the corpus cavernosum. The latter technique, using the femoral artery as the source of blood flow, has been associated with priapism, due to excess blood flow, and surgical failure. Recently, Michal has carried out an end-to-side microsurgical anastomosis of the IEA to the dorsal penile artery when phalloarteriography showed that the arteriosclerotic block was proximal to the bifurcation of the dorsal and deep penile arteries.[6]

American experience with CCR has been disappointing.[7-10] American surgeons have used a variety of techniques in small series so that intimacy with surgical technique has not been developed here. In general, microsurgical technique and prolonged systemic anticoagulation have not been

used. Because of poor results, the value of CCR has been doubted in the United States.

European results have been more encouraging. Ginestié, of Montpellier, France, using direct epigastrico-cavernostomy in 50 patients, has reported 50 percent to 60 percent functional success in resuming sexual intercourse[11,12] and attributes his success to surgical experience, microsurgical technique and the use of systemic anticoagulation before, during and after surgical operation (Ginestié J, personal communication, March 1979). Michal's initial report of microsurgical direct EC included 21 patients.[5] Eight of the procedures were technical failures. However, of the 13 patients in whom patent anastomosis was achieved, nine resumed normal sexual activity. Sarramon, from Toulouse, France, reported on 14 patients treated by anticoagulated microsurgical direct EC with surgical success in eight.[13]

In an effort to duplicate these better results, a series of microsurgical anticoagulated direct epigastricocavernostomies has been undertaken The following is a preliminary report of the first five cases in that series.

Patients and Methods

Patients referred with a diagnosis of impotence were evaluated initially by detailed medical and sexual history and physical examination. Particular emphasis was paid to examination of the abdomen, genitalia, prostate, rectal sphincter tone, perianal sensation, bulbocavernosus reflex, femoral and lower extremity pulses and neurological examination. Water or gas cystometry (or both) was then done. Laboratory evaluation included analysis of urine, examination of expressed prostatic secretions, complete blood count, serum creatinine and two-hour postprandial blood glucose determinations, liver function tests, thyroid function tests, and serum testosterone, follicle stimulating hormone, luteinizing hormone and prolactin studies. Psychological testing using the Minnesota Multiphasic Personality Inventory and nocturnal penile tumescence monitoring were done in most cases to rule out psychogenic impotence. Psychiatric evaluation was done when appropriate. Penile systolic blood pressure measurements were obtained using the Doppler technique. On both sides of the penis the Doppler probe was placed dorsally for the dorsal artery, laterally for the deep artery, ventrally adjacent to the urethra for the spongiosal artery and over the glans for the glans artery. Thus, a total of eight measurements was possible in each case. In most cases, all eight arteries were not audible. The average penile systolic pressure was taken as the average of the audible pulses.

This protocol eliminated from consideration patients with impotence with obvious endocrine, traumatic, pharmacologic, psychogenic, neurogenic and surgical causes. The remaining patients were considered to have vasculogenic or idiopathic impotence. If the ratio of penile to brachial systolic blood pressure was below 0.8,[14] or the

TABLE 1.—*Preoperative Evaluation of Patients*

Patient	*Age*	*Cause of Impotence*	*Duration of Impotence*	*NPTM*	*Penile/Brachial Systolic Blood Pressure*	*Penile Arteriogram*
1	27	Diabetes	2 years	Abnormal	103/130=0.79	Abnormal
2	63	Peripheral vascular disease	11 years	Abnormal	100/170=0.59	Abnormal
3	71	Diabetes	12 years	Abnormal	108/170=0.64	Abnormal
4	50	Penile vascular disease	2 years	Abnormal	85/110=0.77	Abnormal
5	33	Diabetes	3 years	Abnormal	124/125=1.00	Abnormal

NPTM=nocturnal penile tumescence monitoring

TABLE 2.—*Operative and Postoperative Results of Epigastricocavernostomy*

Patient	*Flow in IEA (ml/min)*	*Intra-operative Erection (percent)*	*Complications*	*IEA by Doppler Examination Postoperatively*	*Postoperative Condition*
1	60	50	IEA thrombosis-declotted, repeat anastomosis done within 24 hours	Patent	80 percent normal 0 to 3 months; then 50 percent normal 3 to 12 months; improved, fair functional success
2	15	None	None	Patent	No improvement
3	20	None	Wound infection	Not patent	No improvement
4	..	50	None	Patent	No improvement
5	75	50	None	Patent	90 percent normal 0 to 6 months

IEA=interior epigastric artery

ratio of penile to mean brachial pressure was below 1.0, the possibility of vasculogenic impotence was considered and penile arteriography was done using the technique of Ginestié.[15]

Those patients with distinctly abnormal internal pudendal or penile arteriograms were then given a diagnosis of vasculogenic impotence due to small-vessel disease in the internal pudendal or penile arterial tree. They were offered a choice of surgical alternatives, including semirigid rod prosthetic implant, inflatable penile prosthetic device and corpus cavernosum revascularization. The latter was offered only if the common iliac, external iliac and inferior epigastric arteries were normal on the arteriogram. Diabetes was not considered a contraindication to CCR if the patient had no evidence of peripheral or autonomic neuropathy, normal antegrade ejaculation, normal rectal sphincter tone, normal perianal sensation, normal bulbocavernosus reflex and a normal cystometrogram.

Corpus cavernosum revascularization was accomplished by direct epigastricocavernostomy, using microsurgical technique and systemic anticoagulation. The IEA was exposed through a paramedian incision and isolated up to the level of the umbilicus, where it was transected. It was then brought through the incision in the anterior rectus fascia and passed through a subcutaneous tunnel to the base of the penis. A second short incision at the lateral penile base was used to expose the dorsolateral tunica albuginea. A plug of tunica albuginea was excised and a microsurgical anastomosis of the inferior epigastric artery to the endothelium of the corpus cavernosum was constructed using sutures of 9-0 nylon. Extremely delicate handling of all tissues and detailed attention to the principles of microsurgery were observed at all times. When the anastomosis was complete, the penis was observed for the occurrence of a partial erection lasting several minutes. The wounds were then closed in standard fashion. Anticoagulation was carried out with subcutaneous administration of heparin preoperatively and for four days postoperatively. Therapy was then changed to administration of crystalline warfarin sodium (Coumadin) for six months. The average length of stay in hospital in the uncomplicated cases was eight days.

Results

Five patients with vasculogenic impotence requested corpus cavernosum revascularization. Tables 1 and 2 give the clinical data of these five cases. Figure 1 represents a normal arteriogram of the penile vessels. Figures 2 and 3 are the abnormal penile arteriograms of two patients in this series showing typical stenoses of the penile arteries. The patients' ages ranged from 27 to 71. Preoperatively, patients 2 and 3 were totally impotent, while patients 1, 4 and 5 could achieve 25 percent of normal erectile size and rigidity for short periods of time. All five patients were unable to achieve vaginal penetration. Three patients had diabetes without evidence of neurogenic

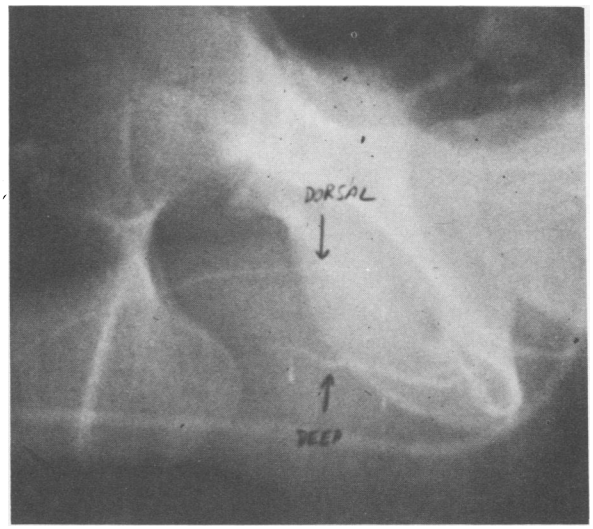

Figure 1.—Normal left phalloarteriogram in right posterior oblique position showing normal appearance of dorsal and deep penile arteries. Distal portion of deep artery is frequently not visualized. Note absence of stenosis and amputation of arteries. Note Foley catheter in urethra. Penis points to patient's right with glans penis at left margin of figure.

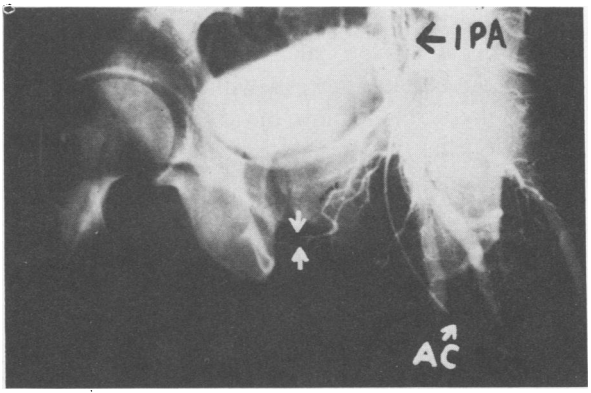

Figure 2.—Abnormal left phalloarteriogram in right posterior oblique position from patient 1 showing amputation of both dorsal and deep penile arteries (arrows). IPA indicates internal pudendal artery leading to penile artery and its branches. AC is arterial catheter.

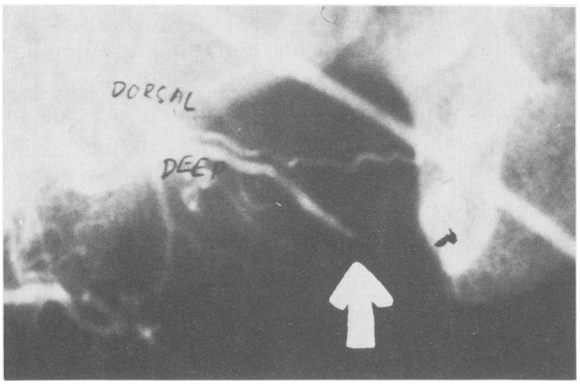

Figure 3.—Enlarged view of abnormal right phalloarteriogram in left posterior oblique posterior position from patient 4 showing pronounced stenosis of deep penile artery (arrow) and dorsal artery of diminished caliber. Diagonal white line is the arterial catheter.

impotence, one patient had widespread peripheral vascular disease and one patient had idiopathic penile vascular disease. The duration of impotence ranged from 2 to 12 years.

Blood flow in the inferior epigastric artery was measured in four of the five cases. This was done in the operating room by direct measurement before anastomosing the IEA to the corpus cavernosum. Liberal topical administration of lidocaine (Xylocaine 2%) helped to prevent vasospasm in the IEA. In the two cases with blood flow of 50 ml per minute or greater, a transient partial erection was observed immediately following the anastomosis. These were the two cases in which there was functional success postoperatively. The first patient had a flow of 50 ml per minute in the operating room and resumed sexual intercourse two weeks after the operation, with erection estimated to be 80 percent of normal. There was then a gradual decline to 50 percent of normal at a year after operation, allowing the patient intermittent functional success with intercourse. Patient 5 had a blood flow of 75 ml per minute in the IEA during the surgical procedure. He also had a 50 percent erection in the operating room immediately following the anastomosis and has resumed sexual intercourse. He states that his erections are 90 percent of normal. The length of postoperative follow-up in this case is six months at present. Patient 4 also had a partial erection in the operating room, but blood flow in the IEA was not measured. There was no improvement in erections postoperatively. Two patients had blood flow below 50 ml per minute. Neither patient had an intraoperative erection following anastomosis, and neither patient benefited from the surgical procedure. There were two surgical complications in the five patients. In the first patient in the series, thrombosis of the transplanted IEA was diagnosed by absence of audible Doppler pulse and by arteriography 24 hours after operation. The patient was returned to the operating room immediately. The anastomosis was taken down, and the artery was declotted with a small Fogarty catheter. A flow of 60 ml per minute was then obtained from the artery. The anastomosis was redone at another site nearby on the corpus cavernosum. In patient 3 a major wound infection developed which responded to prolonged local wound care. Priapism did not occur in any case.

Discussion

Although anatomically suitable, patients 2 and 3 were probably poor candidates for successful corpus cavernosum revascularization because they were chronologically over age 60, had chronic systemic disease making them physiologically even older and had been totally impotent for more than ten years. In both cases, the surgical procedures failed. In both cases, intraoperative flow in the IEA was very poor, and no erection occurred immediately following the anastomosis, possibly predicting functional failure of the operation. It is thought that a flow of 45 to 160 ml per minute is necessary to initiate erection.[5] Blood flow in the normal IEA is 20 to 120 ml per minute,[5] making it suitable as a source of basal blood flow upon which the patient's remaining innate flow can add to produce erection with sexual stimulation. Thus, a baseline flow in the IEA of 50 ml per minute seems to be important for success of epigastricocavernostomy. That concept is borne out in this small series. The two cases in which the flow was 15 and 20 ml per minute were failures, while the two in which flow was greater than 50 ml per minute resulted in definite improvement in erection. Further experience with the reliability of intraoperative IEA flow as a predictor of functional success or failure of epigastricocavernostomy is needed. Also, a method of measuring flow in the IEA preoperatively might be helpful to proper case selection for CCR using the IEA.

The question of whether patients with diabetic impotence should be excluded from candidacy for CCR has not been answered. Many investigators have excluded diabetic patients because of the potential coexistence of neurogenic as well as vasculogenic impotence. In this series, the diagno-

sis of vasculogenic impotence, based on low penile blood pressure and abnormal penile arteriograms, was felt to be secure. The absence of any signs or symptoms of neuropathy, as well as a normal cystometrogram, were taken as sufficient evidence that there was no neurogenic component, and these patients were then included in the surgical group. Of the three diabetic patients, one with only short-term follow-up is cured, one with longer term follow-up was improved and one was a failure. The latter was one of the patients with poor IEA blood flow. These results indicate that diabetic patients should not be excluded from consideration as possible candidates for CCR.

Looking at the entire series, the cure/improvement rate is two of five, or 40 percent. If the two older patients with poor flow in the IEA are eliminated as poor candidates who perhaps should not have been considered for operation in the first place, the cure/improvement rate in the three remaining patients is 67 percent. Corpus cavernosum revascularization is attractive to patients because it offers a chance to regain natural erections without the use of prosthetic material. Should it fail, implant surgical procedures can then be done; these are not precluded by a previous attempt at CCR. The use of microsurgical technique and perioperative heparin administration followed by at least six months of crystalline warfarin sodium therapy may significantly improve the results of CCR, as claimed by Ginestié. Surgeons trained in microsurgery will rapidly appreciate the advantages of microsurgical technique in dealing with an artery, such as the distal IEA, with a diameter of 1 to 2 mm. This surgical procedure is tedious, requiring much attention to fine detail and ample microsurgical experience.

Conclusion

As increasing experience is gained with CCR, its proper role in the treatment of erectile dysfunction will become more clearly defined. Penile revascularization may have its greatest applicability for those patients with partial, but inadequate, erections who still have enough penile blood flow remaining with sexual stimulation to produce an erection when added to the increased basal flow resulting from this operation. Many of these patients are initially unwilling to proceed to prosthesis implantation. Perhaps CCR will be helpful to these patients until such time as the basal plus stimulated penile flow deteriorates below the threshold for erections. These patients may then proceed to prosthetic implantation, which is not compromised by the previous revascularization surgical procedures. In the meantime, it is possible that they will have gained a reasonable period of adequate sexual function without the use of prosthetics. This role for CCR is, of course, speculative and remains to be validated by subsequent experience.

At present, immediate requirements in this field are for (1) basic and clinical research to improve our knowledge of the physiology of erection, (2) research into the hemodynamics and morphology of penile revascularization and (3) perfection of surgical techniques that will allow creation of long-term patent vascular anastomosis of the donor vessel and corpus cavernosum.

As further experience with CCR is gained, it is reasonable to expect initial technical and functional results to improve with refinement of surgical indications and technique. The initial results of this small series, coupled with several reports from Europe, are sufficiently encouraging to justify continued clinical investigation and surgical experience with penile revascularization for vasculogenic erectile dysfunction epigastricocavernostomy.

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